National Action Plan for Energy Efficiency
Sector Collaborative on Energy Efficiency
Office Building Energy Use Profile

It has been estimated that as much as 30% of the energy consumed in office buildings is wasted. This suggests a significant opportunity for energy use reduction, cost savings, and the mitigation of greenhouse gas emissions through cost-effective energy efficiency opportunities. To help identify the best opportunities, both from the perspective of the building owner and the utility, it is important to examine how, where, and when energy is used and the savings are likely to occur.

The following profile will first provide high-level energy consumption and cost metrics for the office building sector. Next, representative daily load shapes for a typical office building will be presented; one of these load shapes will reflect a "baseline" building scenario, while the others will represent this same building following the implementation of a package of cost effective energy efficiency measures. Finally, these building scenarios will be benchmarked with the EPA's energy performance rating system in order to demonstrate the relationship between energy use and the 1-100 rating.

Average Energy Consumption, Cost, and End-Use Figures

Across the United States, the average annual energy intensity for office buildings is 79.8 kBtu per square foot and the average cost is $1.65 per square foot. Of the total energy consumption, 66% is for electricity and 34% is for natural gas and other fuels. This translates to 15.5 kWh per square foot of electricity and 0.27 therms per square foot of natural gas[1].

As show in Figure 2, space conditioning and lighting together account for 70% of all energy consumed in a typical office building, with an additional 20% of energy consumption used to power office equipment. The remaining energy is consumed by water heating, cooking, and refrigeration systems, as well as other miscellaneous uses.

Table 1 – Annual Energy Consumption per Square Foot

	Consumption per Square Foot (Billing units)	Energy Use Intensity (kBtu/sf)
Electric	15.5 kWh/sf	53.0
Natural Gas	0.27 therms/sf	26.8
Total		**79.8**

Figure 1 – Energy Consumption by Fuel Type

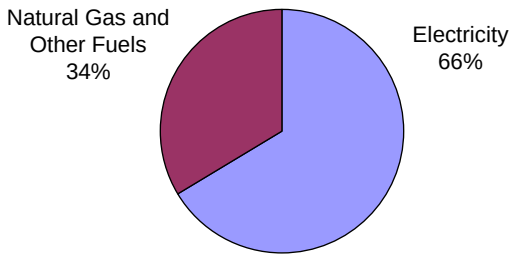
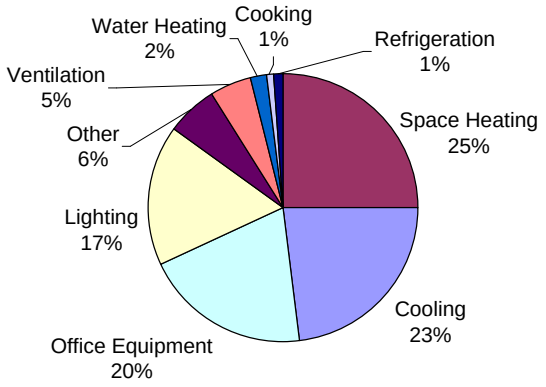


Figure 2 – Total Energy Consumption by End Use
Adapted from E Source, 2006



[1] Based on the 2003 EIA Commercial Building Energy Consumption Survey (CBECS). For the purposes of illustration, all non-electric energy consumption has been converted to the equivalent consumption of natural gas. Other fuels may include oil, steam, and propane.

Office Building Energy Use Profile

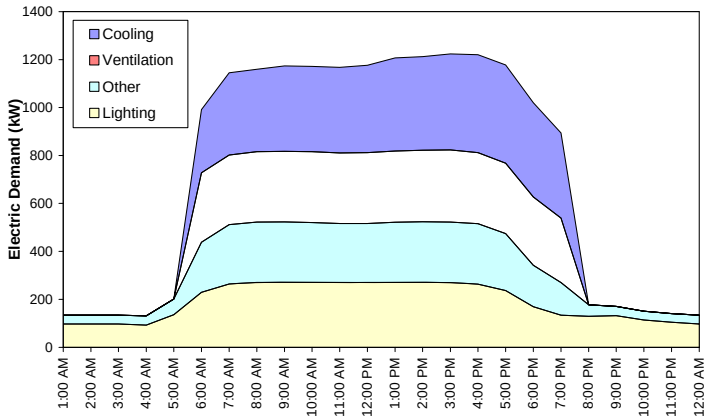
Daily Load Shape

Load Shape – Baseline Scenario: The load profile below represents a baseline scenario for daily operations at a "typical" office building on a summer weekday[2]. This load profile illustrates the contributions of lighting, cooling, ventilation, and other loads throughout the day. Total building energy consumption in offices ramps up quickly in the morning as building systems are brought on line to prepare the property for occupancy. Once systems are online, demand is relatively steady throughout the day. As the working day draws to a close, building systems are taken off line and the resulting electricity load drops accordingly.

Figure 3 - Typical Office Building Load Profile – Baseline Scenario

Assumptions

- High rise office building
- 250,000 square feet
- Centrifugal chiller / gas-fired hot water boiler
- 7:00am – 6:00pm, Mon-Fri
- Chicago, Illinois
- Typical summer day

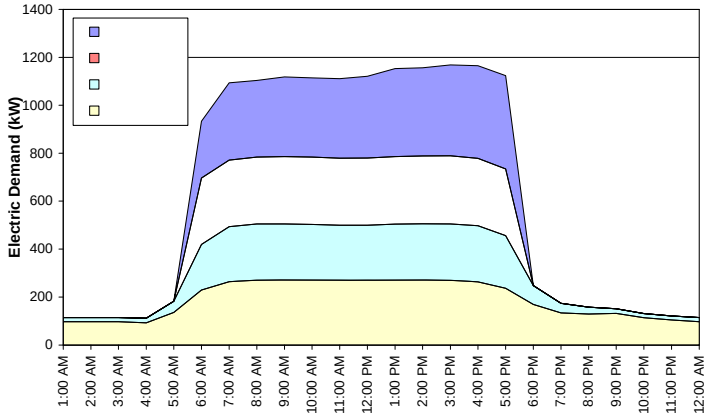


With Efficiency Measures: The following load profiles illustrate the "typical" office building after the implementation of three different packages of energy efficiency measures. Operations and maintenance or re-commissioning measures generally represent low or no cost opportunities that should be a first step in energy management efforts. Lighting measures require capital investment, but have a relatively low simple payback. The full package of measures includes more comprehensive equipment upgrades.

Figure 4 – Load Profile with Operations & Maintenance / Re-commissioning Measures

Measure List

- Optimize Temperature Setpoints
- Optimize HVAC Scheduling
- Optimize Ventilation to Minimum Required for Code
- Chilled Water Reset Controls
- Implement Janitorial Best Practices
- Power Management Enabling for PCs, Printers, and Copiers
- Turn off Plug Loads at Night
- Specify ENERGY STAR Equipment – Office Equipment, Vending Machines



[2] Load profiles were developed using eQUEST, a DOE-2 based software tool.

Figure 5 – Load Profile with Lighting Measures

Measure List

- Efficient Lighting (High Performance T8/T5s, CFLs, LED Exit Signs)
- Occupancy Sensors
- Perimeter Daylighting Controls

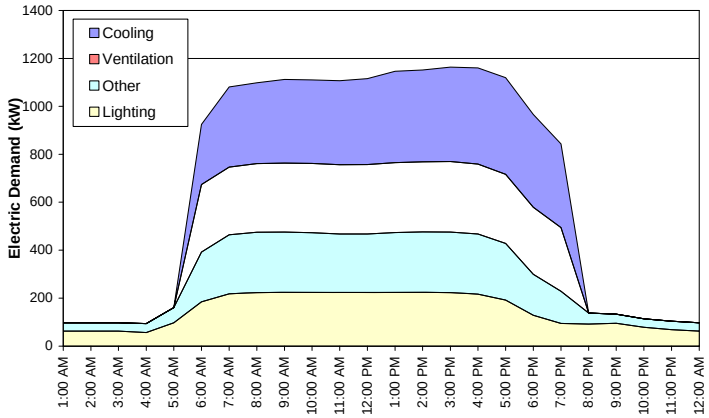
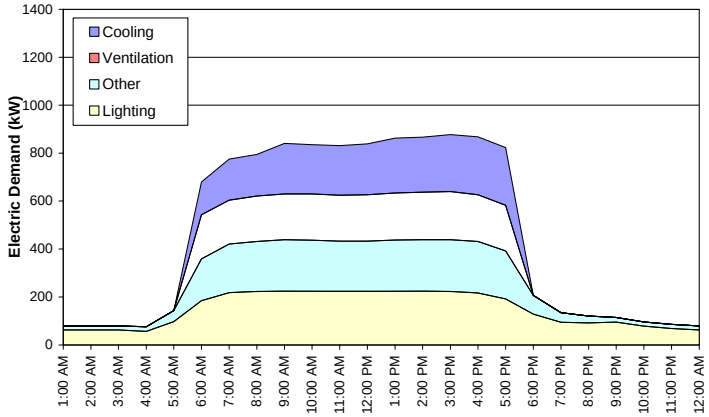


Figure 6 – Load Profile with All Measures

Measure List

- Includes all O&M / Re-commissioning measures
- Includes all Lighting measures
- High-Efficiency Chillers
- Variable Speed Pumps and Fans
- Premium Efficiency Motors



The load profile after the implementation of operations and maintenance measures shows the greatest savings at the beginning and end of the work day due to the shortening of HVAC schedules. It also shows a reduction in peak demand from temperature setpoint changes, and a reduction in overnight energy consumption from turning off unnecessary lights and equipment. The lighting measures result in savings during the work day as a result of more efficient lighting technologies, and savings overnight from lighting controls. In addition to the savings from O&M and lighting, the load profile with the full package of measures shows reductions in peak cooling demand as a result of high efficiency chillers and variable speed drives. The total reduction in peak demand for this building on a typical summer day is 347 kW, or 22% of the baseline.

On an annual basis, the savings from the full package of measures results in a reduction in energy intensity of 22 kBtu per square foot, or 23% of the baseline. This translates to $133,262 per year at national average utility rates of $0.094 per kWh and $1.16 per therm[3].

The energy performance of each of these building scenarios can be benchmarked using the EPA's energy performance rating system. This tool allows building owners and operators to enter building attributes and consumption data and obtain a 1-to-100 rating, normalized for weather and occupancy, which compares a given building to its peer group. In the baseline scenario, the

[3] Based on Energy Information Administration data for 2006.

property received a rating of 62.[4] Factoring in the hypothetical energy efficiency measures that were applied to this building, the energy performance rating increased to 85.

Annual electric and natural gas savings, energy intensity savings, peak demand reductions, cost savings, and energy performance ratings for each of the energy efficiency measure scenarios are included in Figure 7.

Figure 7 – Energy Savings Summary

Scenario	Electric Use (kWh)	Electric Savings (kWh)	Electric Savings (%)	Natural Gas Use (therms)	Natural Gas Savings (therms)	Natural Gas Savings (%)	Annual Energy Intensity (kBtu/sf)	Energy Intensity Reduction (%)
Baseline	3,760,000	--	--	109,500	--	--	95	--
O&M	3,306,000	454,000	12%	90,500	19,000	17%	81	**15%**
Lighting	3,471,000	289,000	8%	112,900	-3,400	-3%	93	**3%**
All Measures	2,483,000	1,277,000	34%	98,100	11,400	10%	73	**23%**

Scenario	Peak Demand (kW)	Demand Reduction (kW)	Demand Reduction (%)	Energy Cost ($)	Energy Savings ($)	EPA Energy Rating
Baseline	1224	--	--	$480,460	--	**62**
O&M	1169	56	**5%**	$415,744	**$64,716**	**74**
Lighting	1164	60	**5%**	$457,238	**$23,222**	**66**
All Measures	877	347	**28%**	$347,198	**$133,262**	**85**

[4] Assumptions entered into Portfolio Manager include 250,000 square feet, 800 occupants, 900 personal computers, and 55 hours of operation per week.